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(54) A terminal for a system requiring secure access.

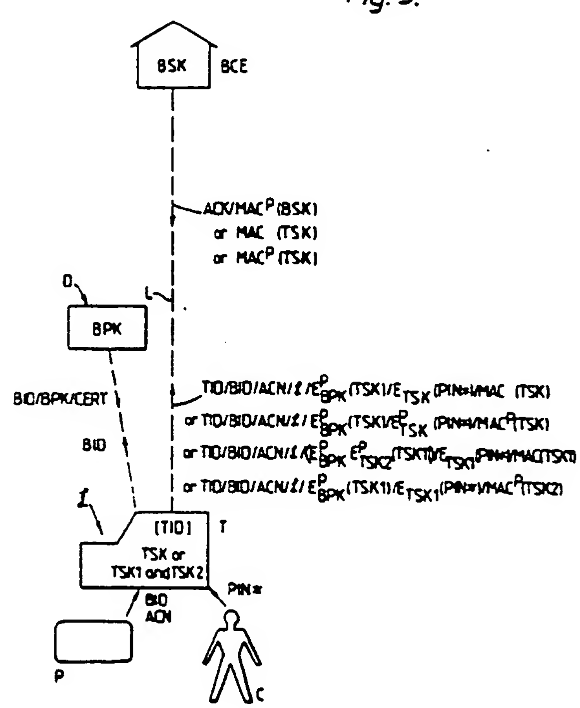
(57) This invention relates to a terminal by means of which users may communicate in a secure fashion with a second party, eg a bank, in order to transact business, eg transfer funds. The user must be verified to the second party before business can be transacted; and it is advantageous if, in addition, the terminal is able to verify the second party that is genuine.

In order to achieve this verification the terminal encrypts information about the user's identity using a selected key, then encrypts the selected key using a public key, corresponding to a secret key held by the second party, before transmission. The selected key may be a conventional key or a second secret key corresponding to a second public key. Multiple encryptions of the selected key are also described.

In a preferred embodiment the terminal also sends a cryptographic checksum to the second party based either on the selected key or a secret key.

The invention also includes a system using such a terminal.

Fig. 3.



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A TERMINAL FOR A SYSTEM REQUIRING SECURE ACCESS

The invention relates to: a terminal for a system requiring secure access, the terminal having means capable of reading data stored in a card or other token, means for entry by the card user of a personal identifier, and means for encrypting the personal identifier prior to transmission to a checking entity; or a system requiring secure access including such a terminal.

The invention particularly relates to a terminal for a system for the electronic transfer of funds, and although not limited to terminals for such systems, will be described with reference to such systems.

Figure 1 illustrates a known electronic funds transfer system. A terminal T is assumed to be located at a retailer's premises for goods purchased there, though the identity of the recipient of the funds to be transferred is not material; the system might also be applied to a cash dispensing machine.

The terminal has a card reader for reading a card P presented by a customer C. The terminal T communicates with the bank that issued the card, or the entity performing checking on behalf of the bank -indicated as bank checking entity BCE -or a centre acting on its behalf, by a telecommunications link L. The terminal has input means, such as a keyboard, for entering data relating to the transaction, such as the amount to be transferred, and for entering the customer's personal identifier.

The transfer of funds from the card-issuing bank to the retailer's bank can be carried out by any convenient means and is not described here.

In order to minimise fraud, it is necessary that the bank should adequately verify the card and the customer. It is also necessary that the retailer's terminal can verify that the bank is genuine.

The extent to which each piece of equipment involved in the process can be regarded as secure depends on the security of the premises on which it is located; thus while the bank may be regarded as "trusted", the terminal T and link L are not.

The customer's personal identifier -generally a number (often abbreviated PIN) is regarded as particularly confidential and in the arrangement shown is encrypted before transmission to the bank for checking. The message format used is indicated in the figures and comprises terminal identity (TID) (stored in the terminal), bank identity (BID), and account number (ACN) (both read from the card), the number to be transferred (£) (entered into the terminal) and the customer identifier entered into the terminal by the customer (this is designated PIN* since it may or may not be the true identifier).

This latter is encrypted using an encryption algorithm in dependence on two keys; a terminal key KT and a key KP stored on the card. This ensures that the encoded personal identifier can be decrypted only by the bank and also serves to verify both the terminal and the card.

Encryption, here and below, is indicated by a letter E with the key(s) shown as subscripts and the data to be encrypted in brackets.

The message is further verified by a message authentication code MAC which is a cryptographic checksum of the message and is generated using KP and KT ie MAC (KP,KT). (The encrypted PIN could be reproduced verbatim by an eavesdropper and does not itself provide sufficient verification).

The bank decrypts the personal identifier and authentication code and acknowledges the message, appending a similar authentication code, ie MAC' (KP, KT), which serves to verify to the terminal that the bank is genuine since only the bank would "know" both KP and KT.

An alternative, permitting the personal identifier comparison to be carried out at the terminal (thereby speeding up the procedure if the customer makes an error in entry) -but without disclosing the identifier to the terminal involves the terminal sending tc the bank the same message as before but with a random number TRN substituted for the personal identifier viz TID/BID/ACN/£/$E_{KP,KT}$(TRN)/MAC(KP, KT). When the bank acknowledges it returns the random number encrypted using KP, KT and the true identifier PIN as keys, ie $E_{KP,\ KT,\ PIN}$(TRN). The terminal has available KP, KT and TRN the nature of the encryption is such that the terminal cannot decrypt the PIN; it can, however encrypt the identifier PIN* offered by the customer and compare it with that sent by the bank, ie the comparison: $E_{KP,\ KT,\ PIN^*}$(TRN) = $E_{KP,\ KT,\ PIN}$(TRN) ?

The system described with reference to Figure 1 requires a key KP stored on the customers card; cards currently in use do not contain such a key and the present invention offers a secure alternative which does not require this.

The concept of public key cryptosystems will now be introduced. The public key system involves encryption of a message by a sender using a first - (public) keyE^P_{PK}, which can then be decoded by the recipient using a second (different) key known only to him (the private key E^P_{SK}) (E^P denotes encryption using a public key system). The second key cannot be deduced from the first -at least not

without a prohibitive amount of computation. Thus anyone possessing the public key can send a message knowing that it will be understood only by the intended recipient.

In public key systems the recipient will normally transmit his public key in encrypted form to a sender at the beginning of a transaction to avoid the necessity for the sender to store large numbers of keys; however, a possibility of fraud arises if a pirate recipient X intercepts a message from a sender B whilst claiming to be the bona fide recipient A. X cannot send A's public key as then B's reply would be unintelligible to him since X does not know A's secret key. So X offers A's identity but his own (X's) public key. This danger can be avoided by the converse use of public key encryption in which a message is encrypted using a private key and decrypted using a public key, so that the message is authenticated as to its <u>source</u> - (analogous to a signature). This involves the recipient appending a "certificate" to his message. The certificate is a encryptographic checksum of the recipient's identity and his public key (plus, optionally, any other derived data), encrypted using a certification private key known only to a 'certification server' and not to A, B or X who, however, know the certification <u>public</u> key and how to calculate the cryptographic checksums, and so B (in this case) can decrypt the certificate and check that in the alleged identity and key correspond.

Figure 2 illustrates a known electronic funds transfer system using a public key cryptosystem. Although similar to Figure 1, it differs in that in place of the keys KP and KT it employs bank public and secret keys BPK and BSK. The personal identifier PIN* is encrypted at the terminal using the bank's public key BPK (the corresponding secret key BSK is known only to the bank). BPK could be stored in the terminal, or obtained from a central directory D. Either way the bank's public key is stored with the corresponding certificate so that it can be verified by the terminal before use.

The terminal is then able to send a secure message to the bank ie TID/BID/ACN/£/E $^{P}_{BPK}$(PIN*), where the bank checking entity BCE can decrypt the message. The bank can then check the PIN*, transfer the funds requested and acknowledge the transfer. The acknowledgement can include a message authentification code using the bank secret key, ie ACK/MAC^{P}(BSK), to prove to the terminal that it is genuine.

The system described with reference to Figure 2 does not require a key stored on the customers card, but suffers from the drawback that the terminal is not authenticated to the bank.

According to the invention there is provided a terminal for the system requiring secure access, the terminal having means capable of reading data stored in a card or other token, means for entry by the card user of a personal identifier, and means for encrypting the personal identifier prior to transmission to a checking entity, characterised in that the personal identifier is encrypted by means of a selected key, that key being transmitted, after encryption using a public key corresponding to a secret key held by the checking entity, along with the encrypted personal identifier.

Also according to the invention there is provided a system requiring secure access including such a terminal.

The invention will now be described by way of example with reference to Figure 3. Although similar to Figure 2, it differs in that it additionally employs a terminal selected key TSK. This selected key may be a conventional key (like KP and KT), for instance a random or psuedo random number or a private key (corresponding to a public key TPK). In either case the personal identifier PIN* is encrypted using the selected key, ie E $_{TSK}$(PIN*) or E $^{P}_{TSK}$(PIN*), and the selected key is encrypted using the bank public key, ie E $^{P}_{BPK}$(TSK); both are then sent with the message to the bank.

A message authentification code may be generated using the selected key, ie MAC(TSK) or MAC^{P}(TSK), and also sent to the bank. In this way the bank is able to verify that the terminal is genuine.

In an embodiment having additional security the terminal may have a selected conventional key TSK1, and a private key TSK2. In this embodiment the personal identifier PIN* may be encrypted using the conventional key TSK1, ie E$_{TSK1}$(PIN*), and this key may be encrypted using the terminal private key TSK2 and then with the bank's public key, ie E $^{P}_{BPK}$(E $^{P}_{TSK2}$(TSK1)). In this case the MAC may be generated by the conventional key MAC - (TSK1) or the private key, MAC^{P}(TSK2). However, it should be noted that the conventional key does not have to be encrypted by TSK2 before encryption by BPK, in which case the terminal private key can be used to generate only the MAC, MAC^{P}-(TSK2).

In the case where the selected key is a private key it may not be efficient for the bank to store the corresponding public key (TPK) for all the terminals concerned; and in this case the message from the terminals to the bank should include the relevant public key together with a certificate, ie TID/..../E $^{P}_{TPK}$/CERT....

The bank responds to messages from the terminals by sending an acknowledgement ACK, and additionally a message authentification code to prove that the bank is genuine. This MAC may take the form of $MAC^P(BSK)$ or MAC(TSK) or MAC^P-(TSK) (depending on whether TSK is a conventional or private key).

Again the alternative of sending a random number TRN instead of PIN* and carrying out the personal identifier checking at the terminal may be used. For example the terminal sends TRN encrypted with XX, $E_{XX}(TRN)$ instead of $E_{XX}(PIN^*)$ and the bank then returns $E_{XX.PIN}(TRN)$.

At this point it should be recalled that the terminal itself is regarded as "not trusted". Therefore the route between the keypad (or other means) for input of the personal identifier PIN and the means for encryption of the PIN needs to be 'secured' in some way and normally the two will be contained in a physically secure sub-unit within the terminal.

The checking entity CE is referred to as such since although it could in fact be checking equipment located at the card issuing bank -or at some other site, other options are possible. One of particular interest is the possibility of digital processing capability within the card itself -the so-called "smart card". In this instance the PIN checking entity could be incorporated in the card itself - though of course transaction information will still have to be exchanged between the terminal and the bank (though not necessarily at the time of the transaction).

Thus the smart card could itself contain the identifier PIN which can then be internally compared with E^P_{BPK} (PIN*)), or, as described above, the comparison could be carried out in the terminal.

Note throughout that the encrypted forms of PIN (or PIN*) or related random numbers may be required to be different for each transaction. This may be achieved by either (i) combining the PIN - (or PIN related) data with other, variant, data prior to encryption, or (ii) modifying the encrypting key every transaction, or (iii) both.

Finally it should be pointed out that though the customer's personal identifier may be a number, biometric means -such as an automatic fingerprint reader -may be used.

Claims

1. A terminal for a system requiring secure access, the terminal having means capable of reading data stored in a card or other token, means for entry by the card user of a personal identifier, and means for encyrpting the personal identifier prior to transmission to a checking entity, characterised in that, the personal identifier is encrypted by means of a selected key, that key being transmitted, after encryption using a public key corresponding to a secret key held by the checking entity, along with the encrypted personal identifier.

2. A terminal according to claim 1 in which the selected key is a random or pseudo-random number.

3. A terminal according to claim 1 in which the selected key is a second secret key held by the terminal.

4. A terminal according to claim 2 in which a second secret key held by the terminal is used to encrypt the selected key prior to the public key encryption.

5. A terminal according to claims 2, 3 or 4 arranged in operation to append to its transmissions a cryptographic checksum of the message generated using the selected key whereby the message content and origin may be verified upon receipt.

6. A terminal according to claim 2 arranged in operation to append to its transmissions a cryptographic checksum of the message generated using a second secret key held by the terminal whereby the message content and origin may be verified upon receipt.

7. A terminal according to claim 4 arranged in operation to append to its transmissions a cryptographic checksum of the message generated using said second secret key whereby the message content and origin may be verified upon receipt.

8. A terminal according to claims 3, 4, 6 or 7 in which information encrypted by the terminal using a secret key is accompanied by the corresponding (second) public key together with a certificate.

9. A terminal according to any one of the preceding claims, including means for communication with the card or other token, in which the checking entity is located.

10. A system requiring secure access including a terminal according to any one of the preceding claims.

Fig.1.

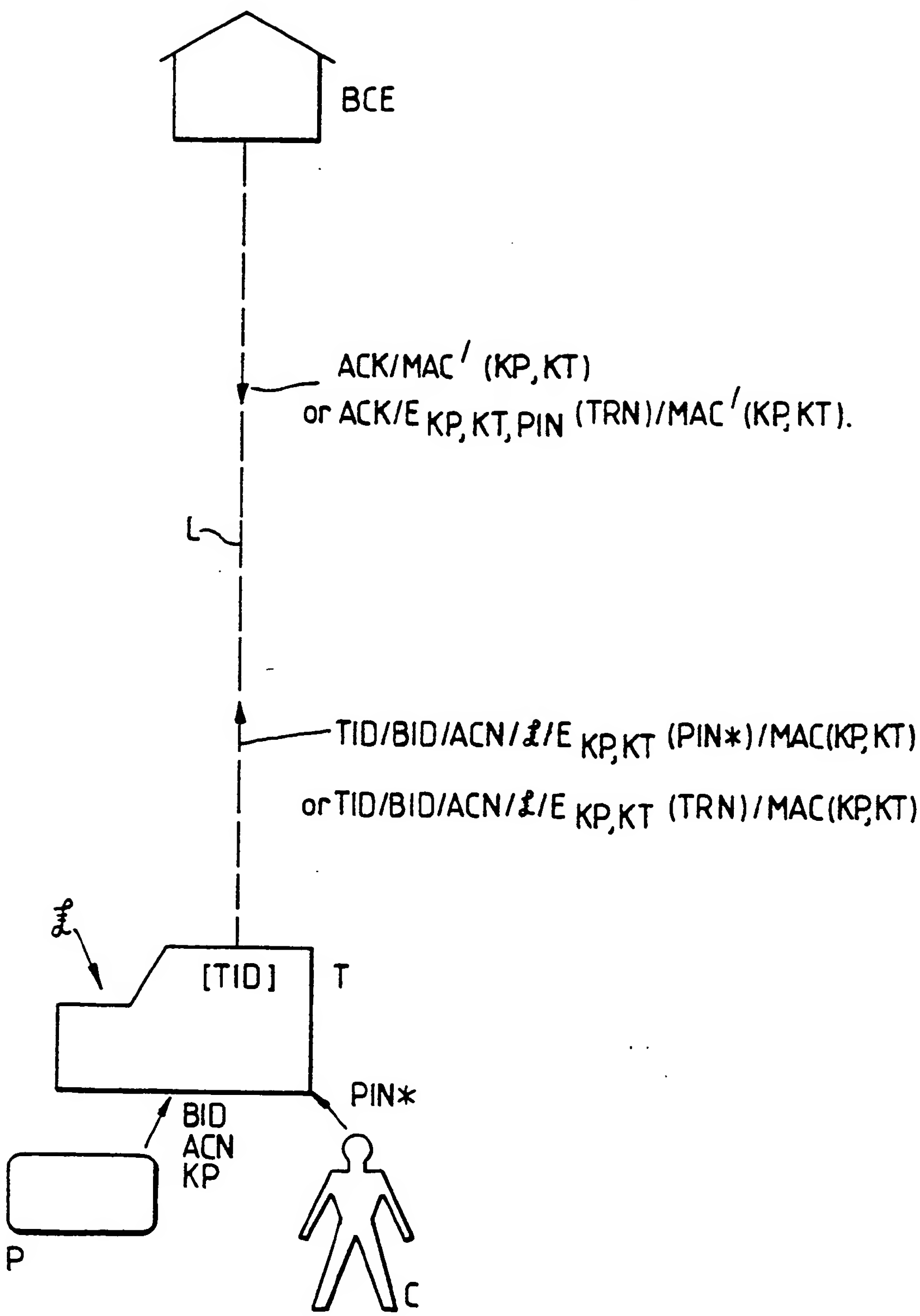
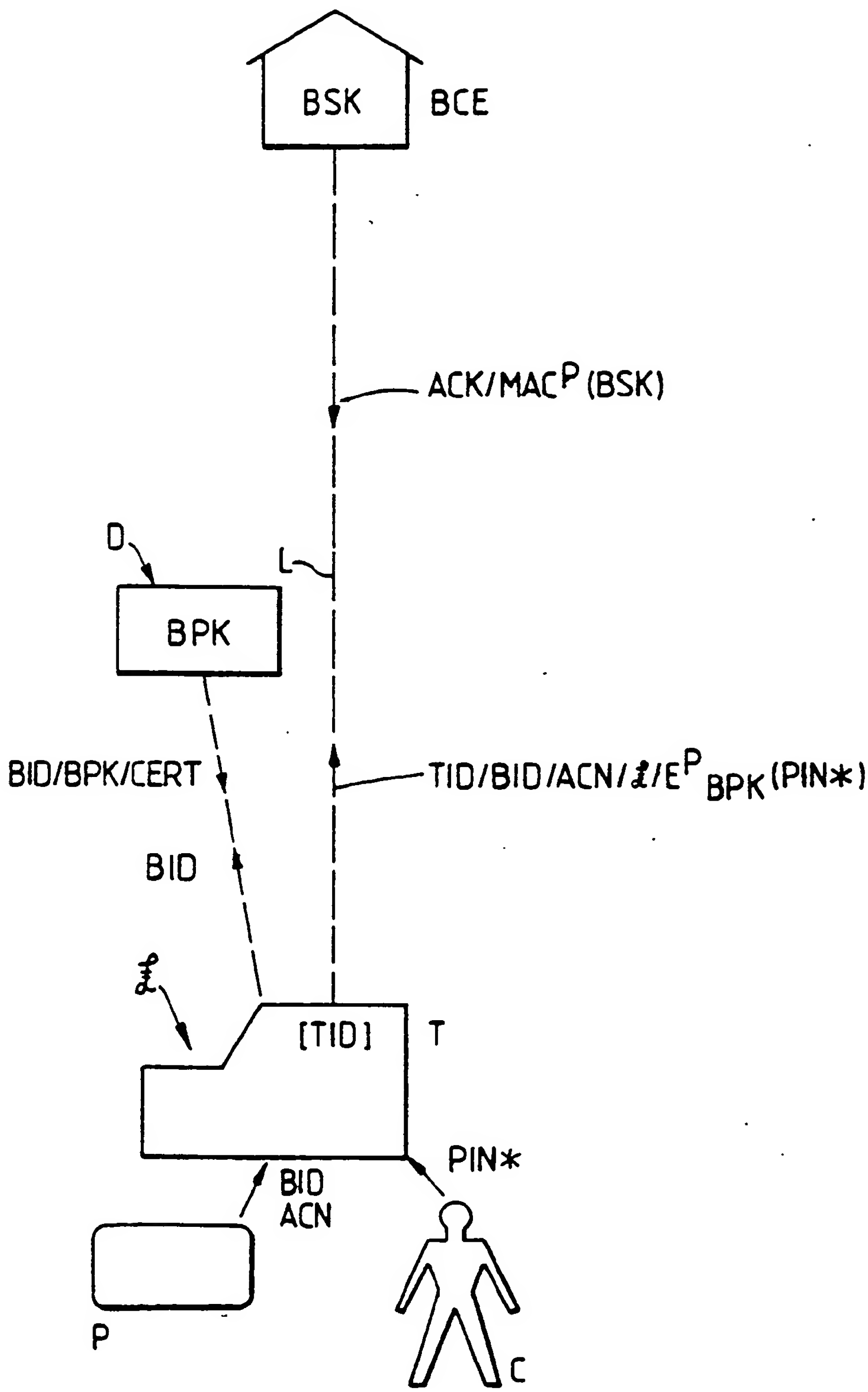
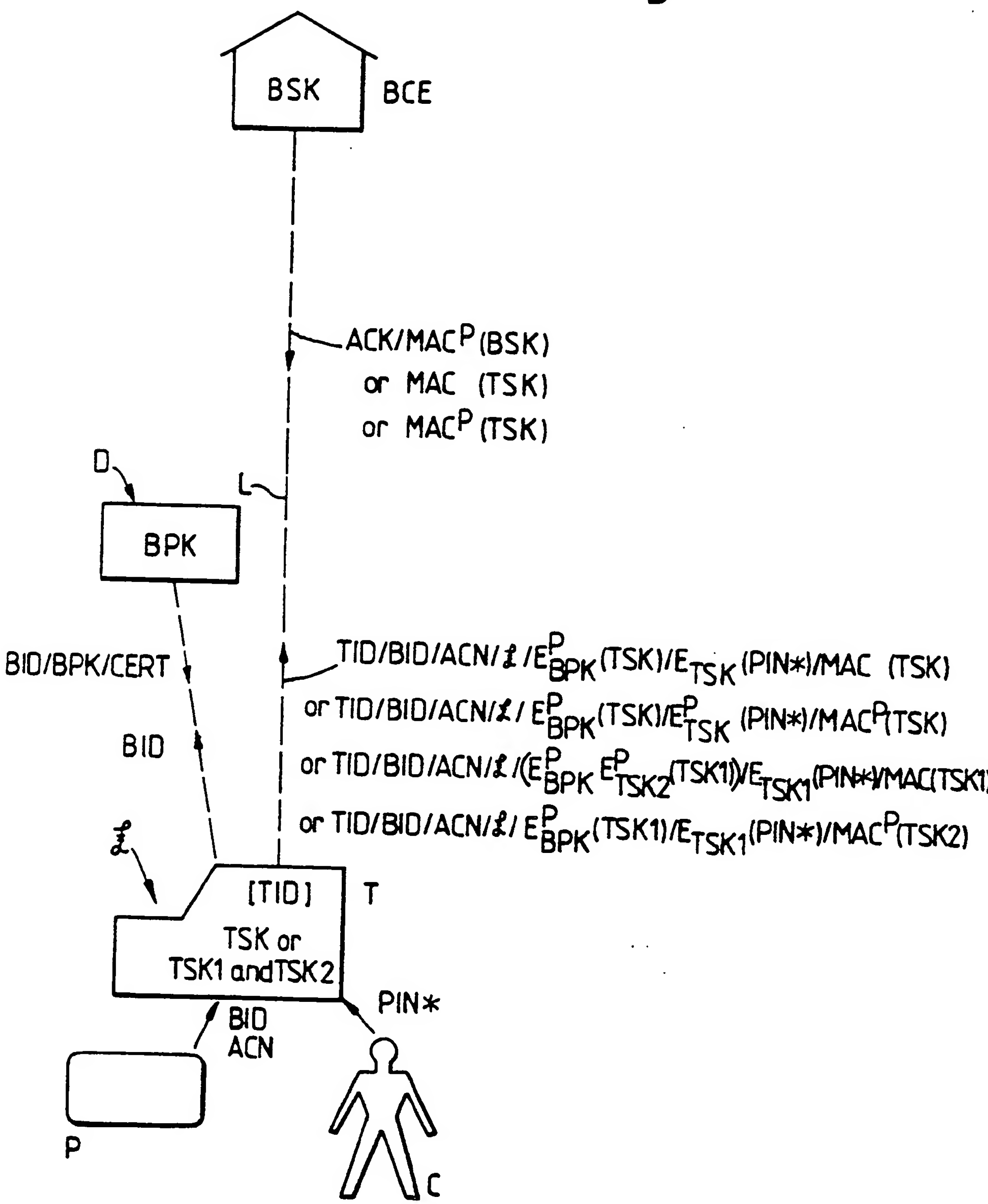

BCE
ACK/MAC' (KP, KT)
or ACK/E KP, KT, PIN (TRN)/MAC'(KP, KT).
L
TID/BID/ACN/£/E KP,KT (PIN*)/MAC(KP,KT)
or TID/BID/ACN/£/E KP,KT (TRN)/MAC(KP,KT)
£
[TID]
T
PIN*
BID
ACN
KP
P
C

Fig. 2.



BSK
BCE
ACK/MAC^{P}(BSK)
D
L
BPK
BID/BPK/CERT
TID/BID/ACN/£/E^{P}_{BPK}(PIN*)
BID
£
[TID]
T
PIN*
BID
ACN
P
C

Fig. 3.


BSK
BCE
ACK/MACP(BSK)
or MAC (TSK)
or MACP(TSK)
D
L
BPK
BID/BPK/CERT
BID
TID/BID/ACN/£/EPBPK(TSK)/ETSK(PIN*)/MAC (TSK)
or TID/BID/ACN/£/EPBPK(TSK)/EPTSK (PIN*)/MACP(TSK)
or TID/BID/ACN/£/(EPBPK EPTSK2(TSK1))/ETSK1(PIN*)/MAC(TSK1)
or TID/BID/ACN/£/EPBPK(TSK1)/ETSK1(PIN*)/MACP(TSK2)
£
[TID]
T
TSK or
TSK1 and TSK2
BID
ACN
PIN*
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C

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EUROPEAN SEARCH REPORT

Application number

EP 86 30 7433

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
Y	WO-A-8 102 655 (M. SENDROW) * Page 5, line 10 - page 12, line 27; page 66, line 1 - page 73, line 36 *	1	G 07 F 7/10 H 04 L 9/02
A		3,6	

Y	US-A-4 438 824 (C. MUELLER-SCHLOER) * Column 4, line 8 - column 10, line 67 *	1	
A		2,5,6, 9,10	
	---		TECHNICAL FIELDS SEARCHED (Int. Cl.4)
Y	IBM TECHNICAL DISCLOSURE BULLETIN, vol. 24, no. 7B, December 1981, pages 3906-3909, New York, US; R. E. LENNON et al.: "PIN protection/verification for electronic funds transfer" * Page 3907, paragraph 2 - page 3909, paragraph 1; figures *	1	G 07 F H 04 L
A	Idem	2	
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	16-01-1987	EXELMANS U.G.J.R.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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Category	DOCUMENTS CONSIDERED TO BE RELEVANT Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
A	EP-A-0 064 779 (N.V. PHILIPS' GLOEILAMPENFABRIEKEN) * Page 11, line 9 - page 12, line 14 * ---	2,4,8-10	
A	DATA COMMUNICATIONS, vol. 14, no. 7, June 1985, pages 213-225, New York, US; M. NEUMAN: "Financial users can bank on new security standard X9.17" ---	5-8	
A	GB-A-2 020 513 (ATALLA TECHNOVATIONS) ---	1	
A	EP-A-0 148 960 (IBM) -----	1	
			TECHNICAL FIELDS SEARCHED (Int. Cl.4)

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